

# Search for $H \rightarrow WW$ at DØ

DPF 2003

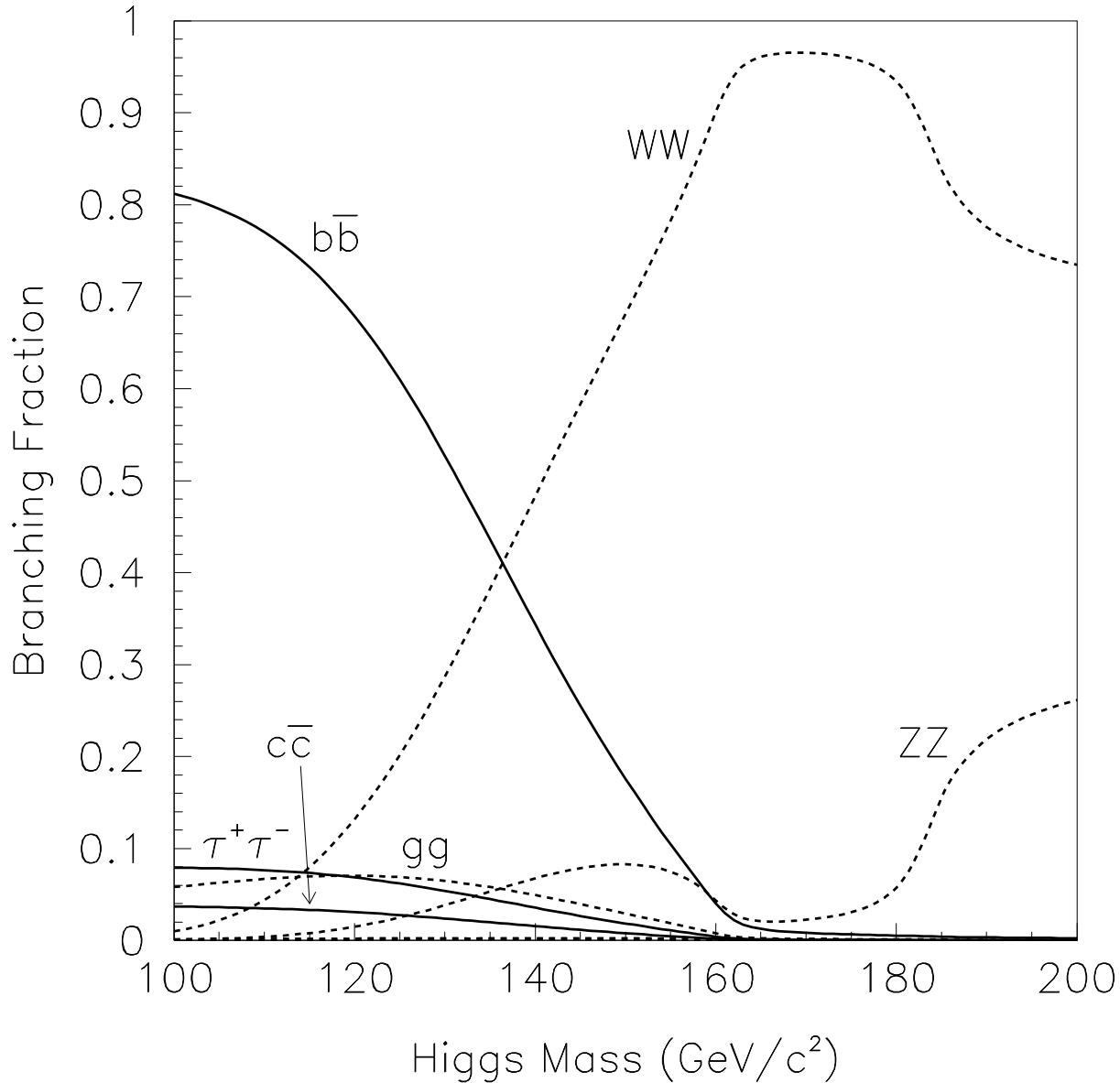
P. Tamburello

*University of Arizona*

for the DØ Collaboration

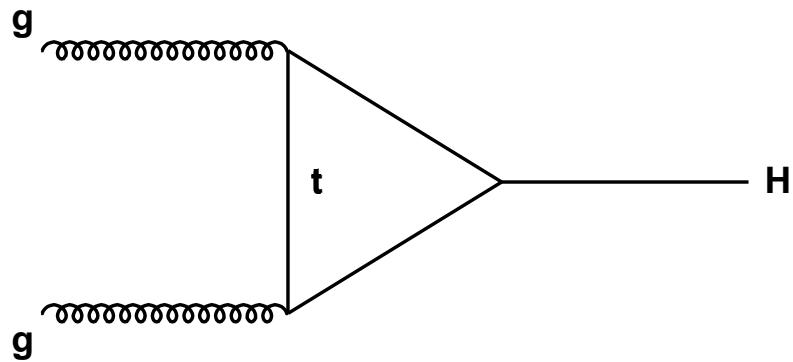
# Standard Model Higgs Decay Modes

HDECAY - Djouadi, Kalimowski, and Spira

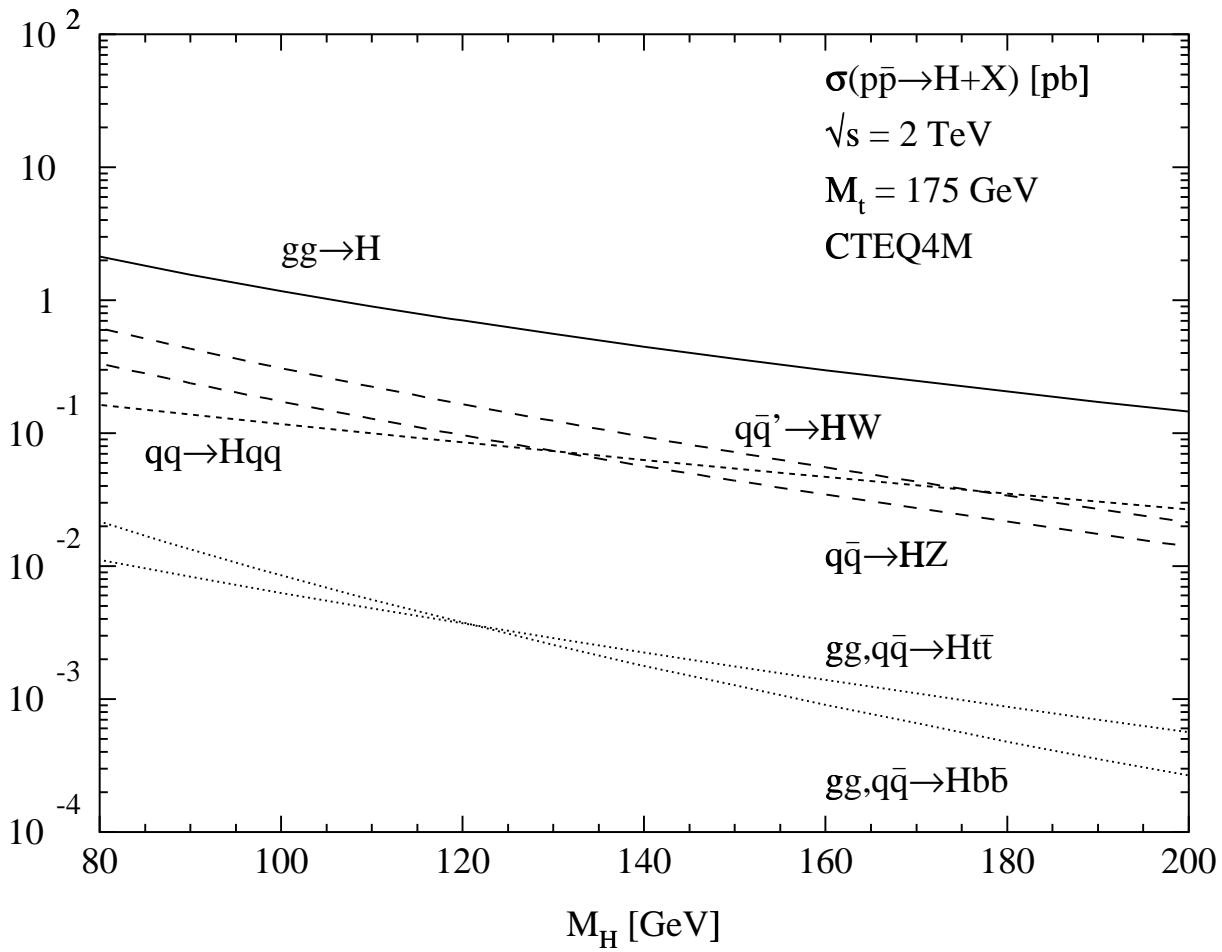


- Look for final states  $e\mu\nu\nu$ ,  $ee\nu\nu$ , and  $\mu\mu\nu\nu$  (new)
- Branching fraction only 5%, but strong interaction backgrounds overwhelm signatures with jets

# Standard Model Higgs Production

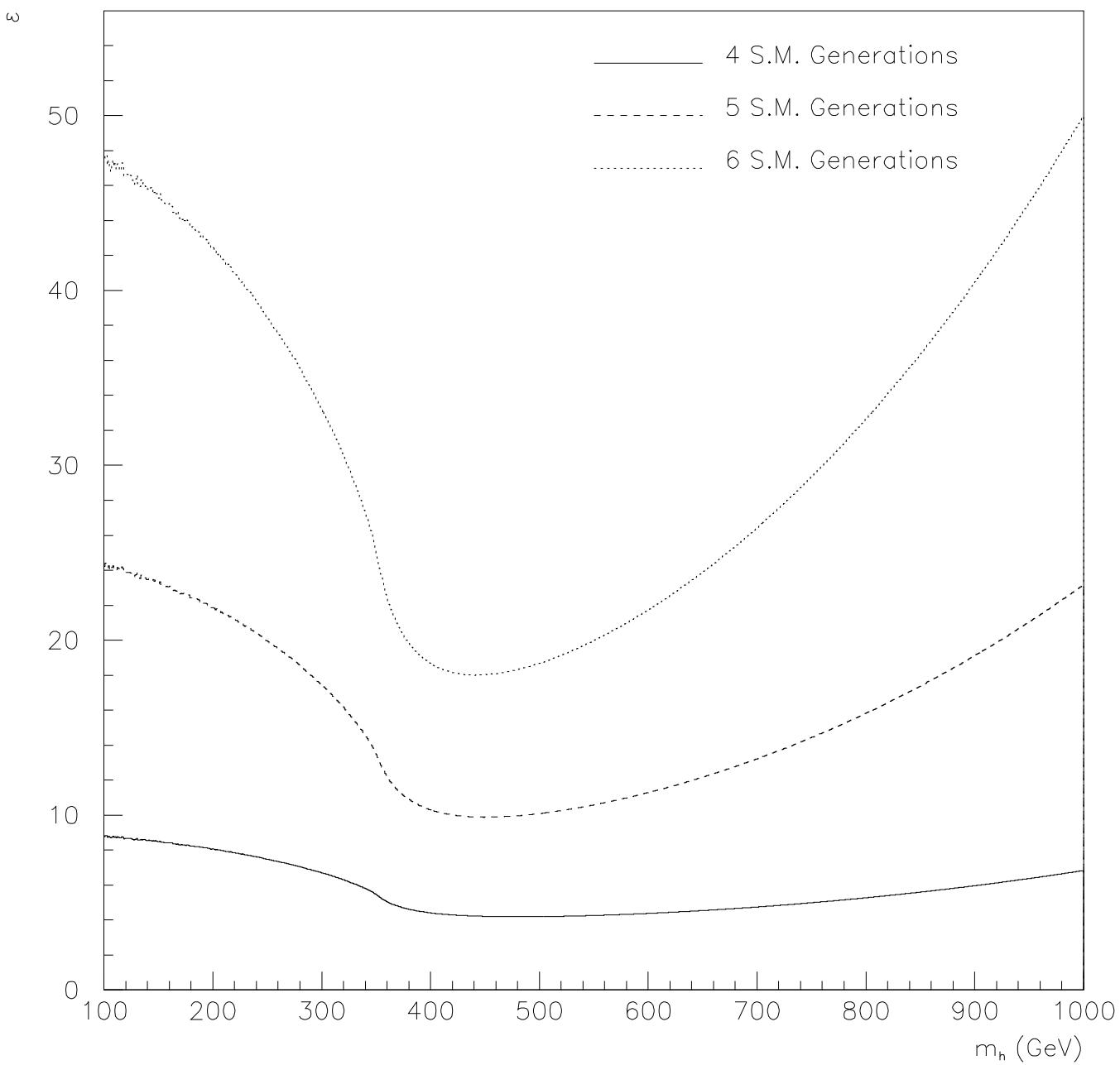


*M. Spira, hep-ph/9810289*



# Cross Section Enhancement from Extra Generations

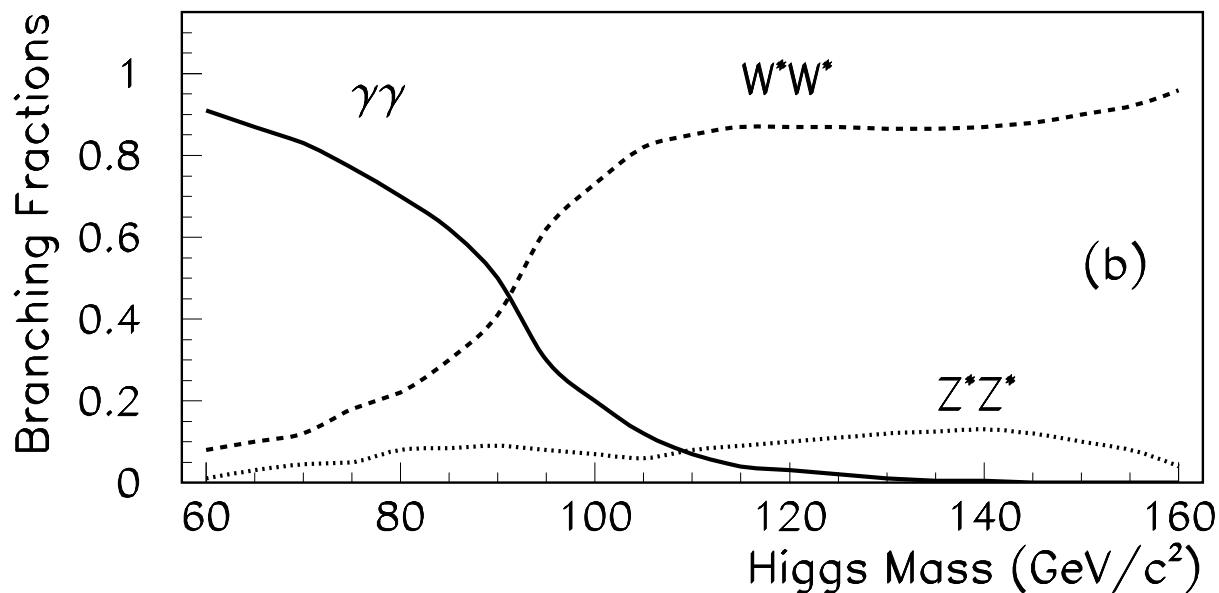
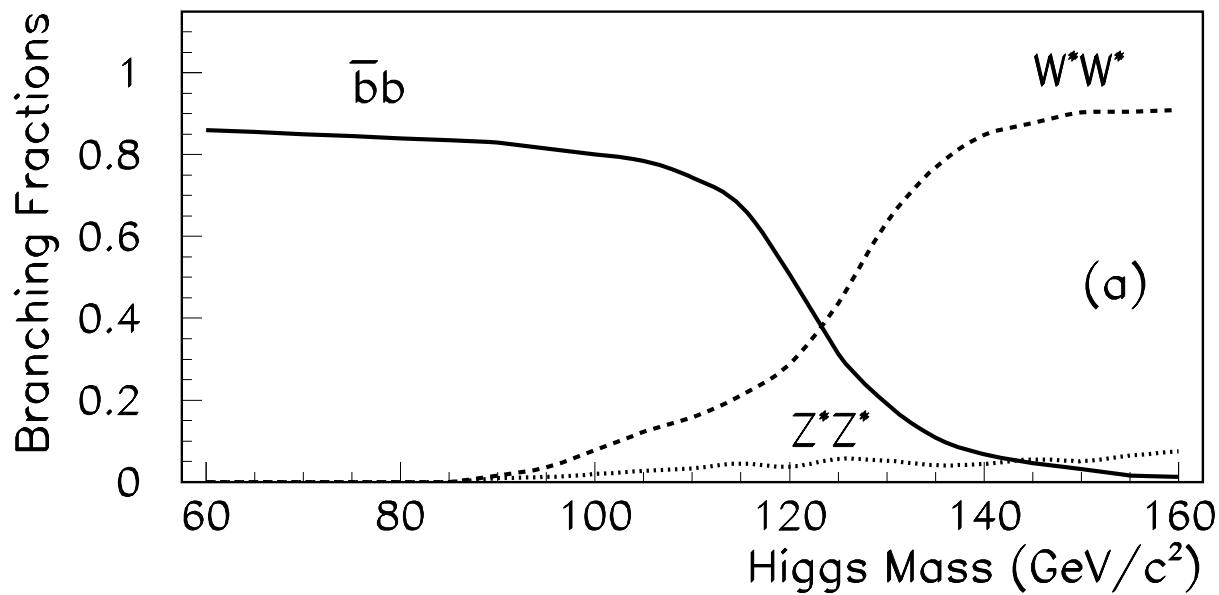
*Arik, Cakir, Cetin, and Sultansoy, PRD 66 (2002) 033003*



## Suppressed Couplings to $b$ , $\tau$

This occurs in many models,  
see A. Melnitchouk, P14.005

*Abbott, et al. PRL 82 (1999) 2244*

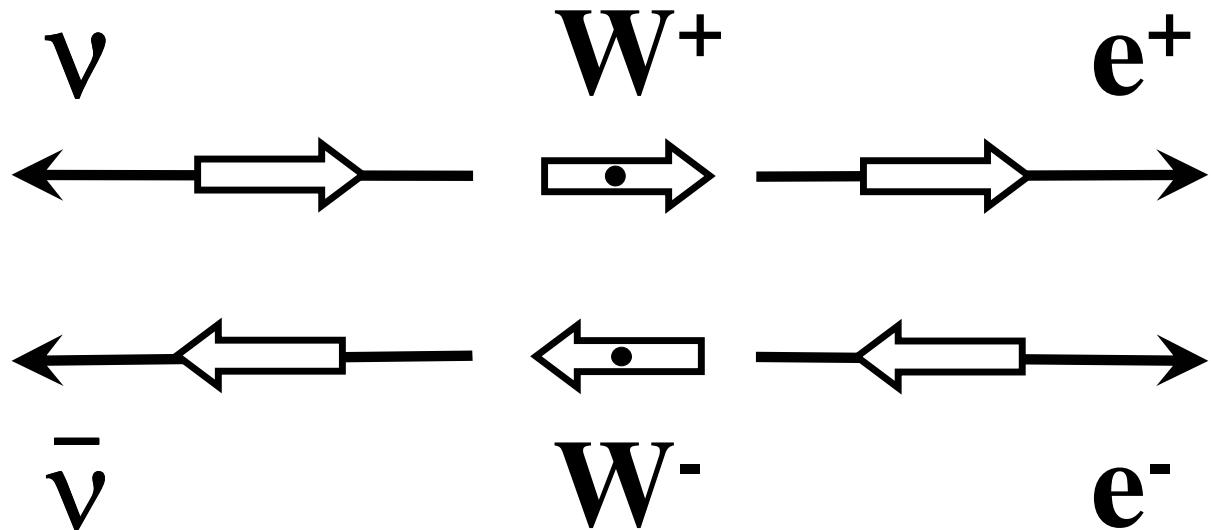


## Spin Correlations

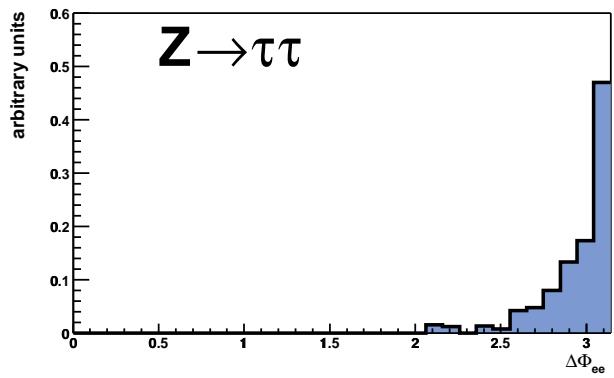
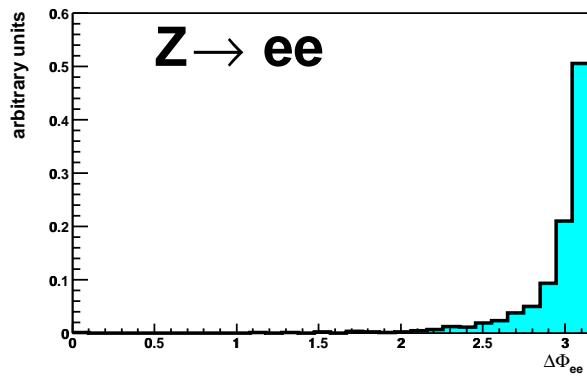
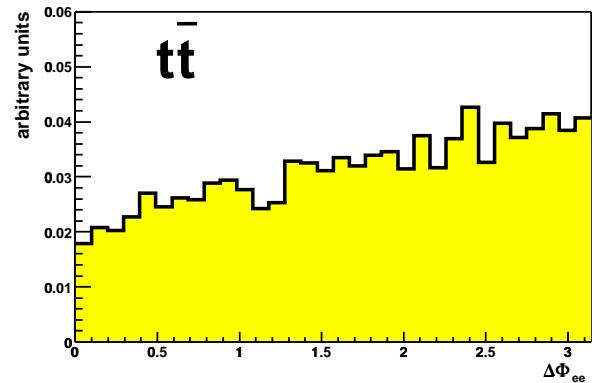
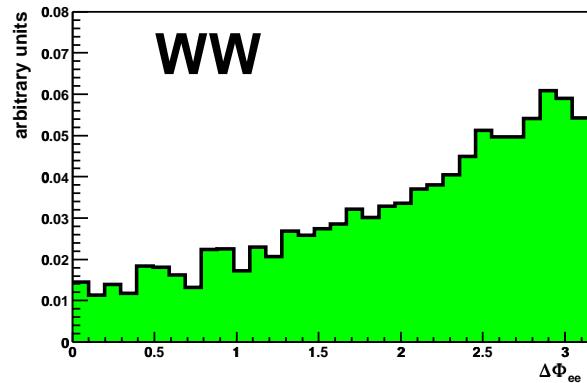
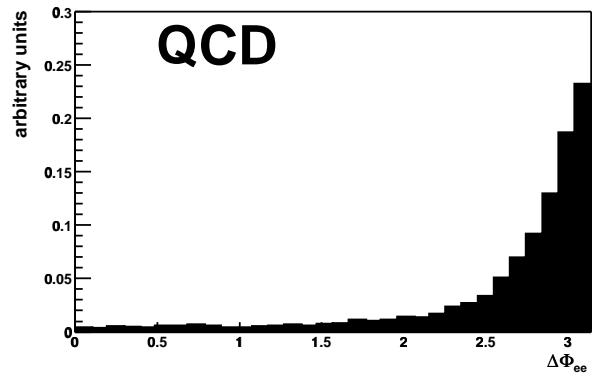
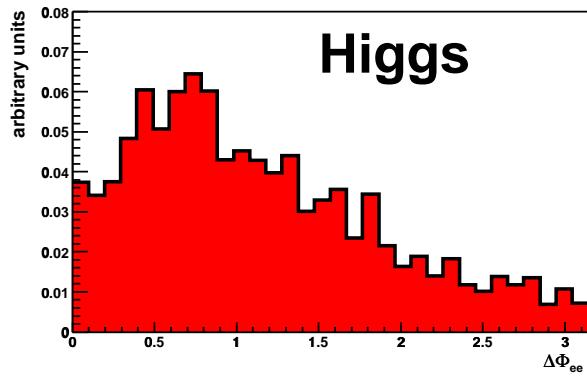
$W \rightarrow$  left-handed particle + right-handed antiparticle  
(weak interaction is V-A)

$$J = 0$$

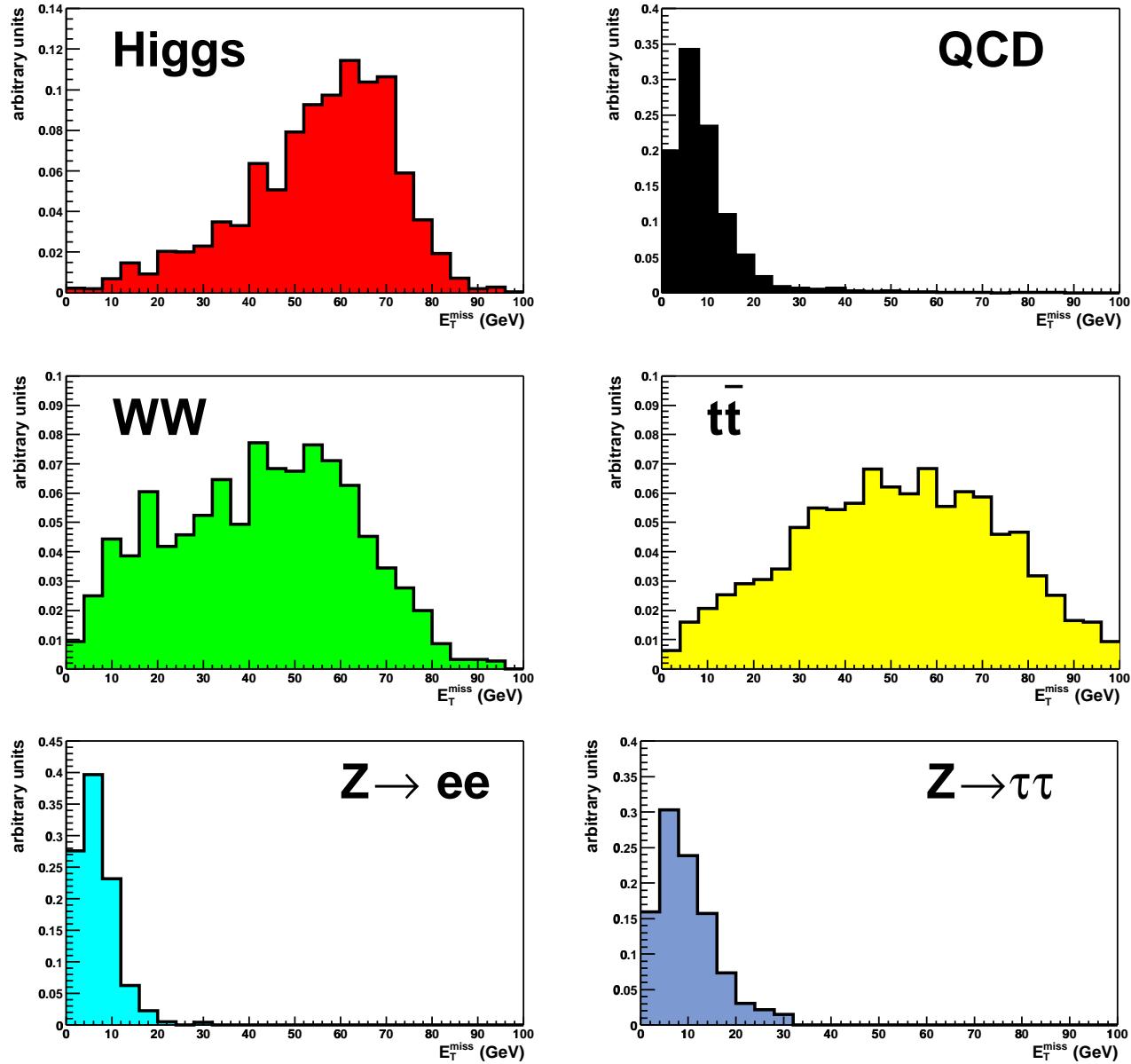
$\Rightarrow$  the charged leptons tend to be parallel to each other,  
likewise the neutrinos



$$\Delta\phi(l, l)$$



# Missing $E_T$ ( $\cancel{E}_T$ )

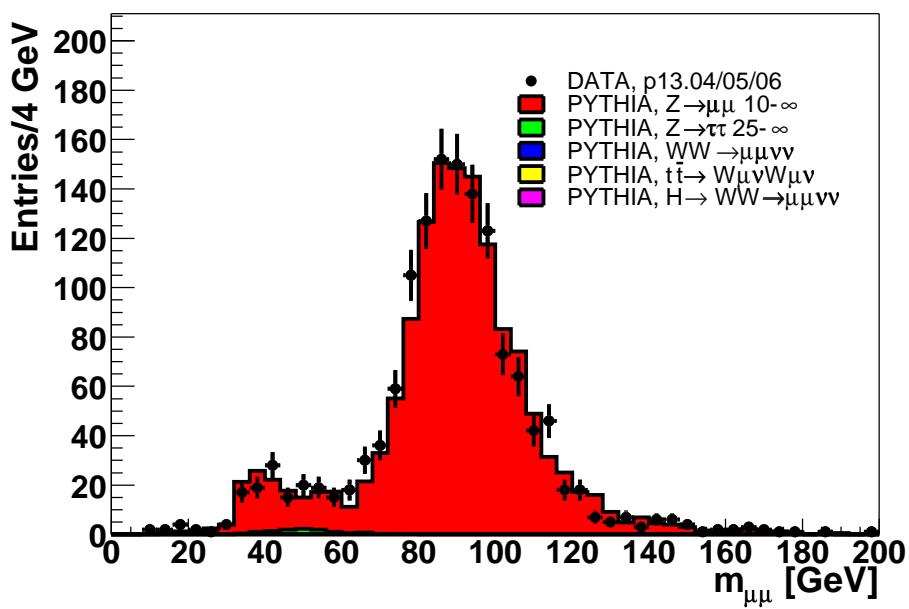
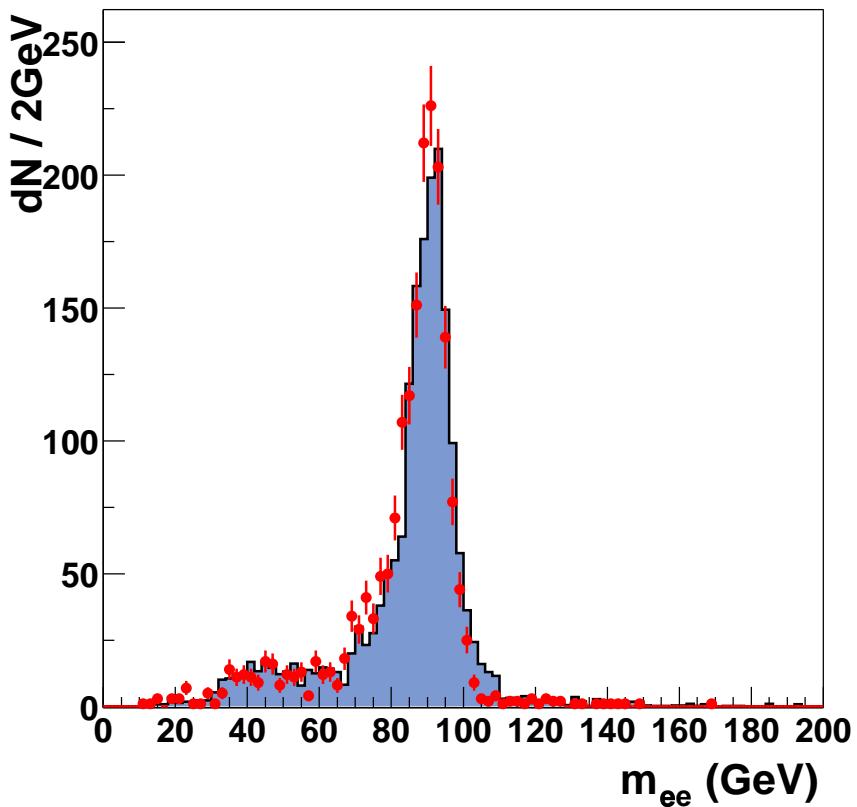


## Dilepton Selection

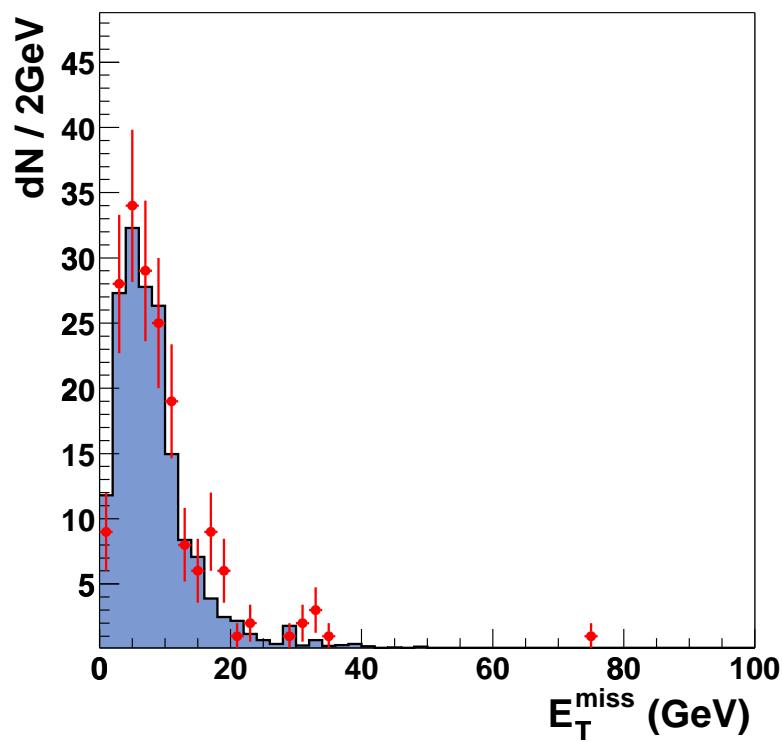
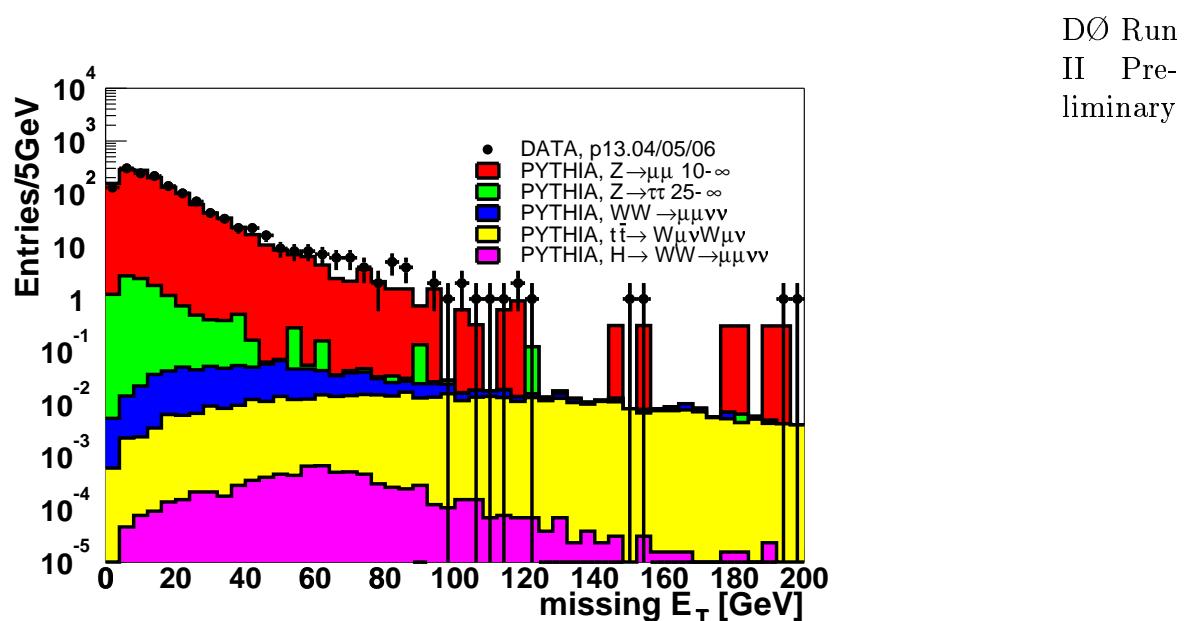
- Require two leptons  $l = e, \mu$ 
  - $ee$ :  $p_T > 20, 10$  GeV
  - $\mu\mu$ :  $p_T > 15$  GeV
  - $e\mu$ :  $p_T^e > 20$ ,  $p_T^\mu > 10$  GeV
- The  $ee$  and  $\mu\mu$  samples are mostly  $Z/\gamma$
- $Z$  removal. Require
  - $ee$ :  $m(e, e) < M_H/2$
  - $\mu\mu$ :  $20$  GeV  $< m(\mu, \mu) < 75$  GeV

$m_{ee}$  and  $m_{\mu\mu}$

DØ Run  
II Pre-  
liminary



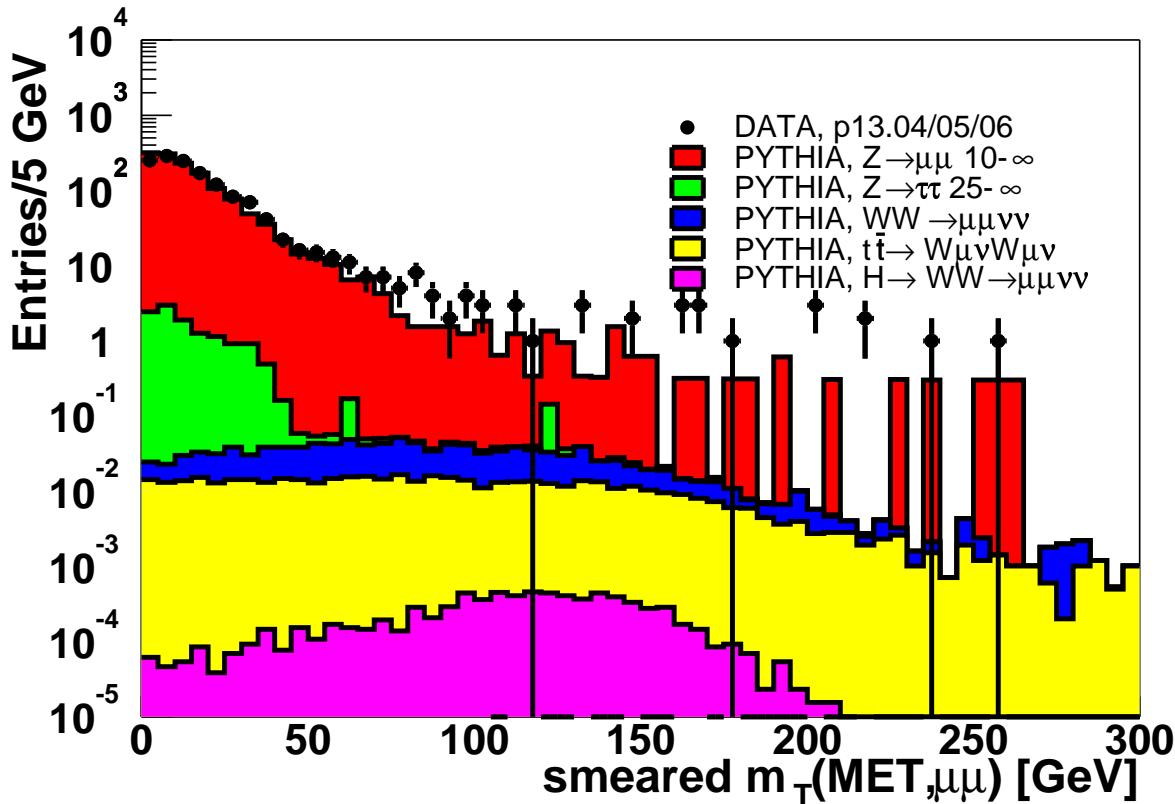
$E_T$



Require  $E_T > 20$  GeV and  $\Delta\phi(j, E_T) > 0.5$

$$m_T(l\bar{l}, \cancel{E}_T)$$

DØ Run II Preliminary

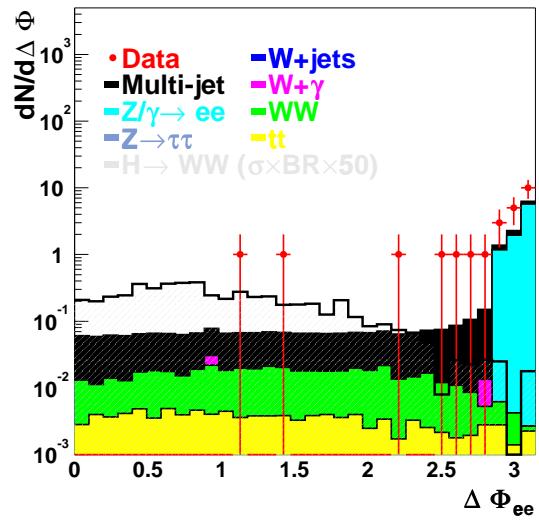
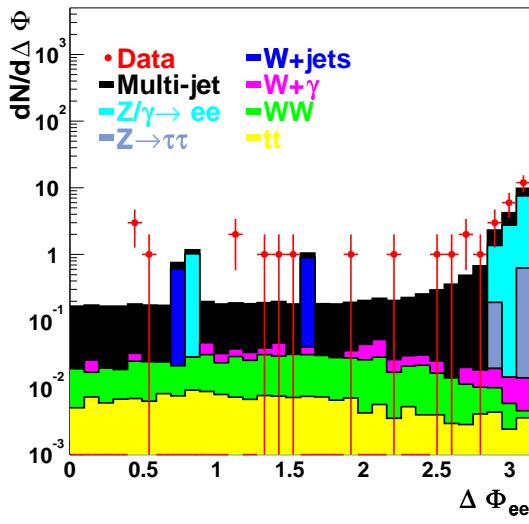
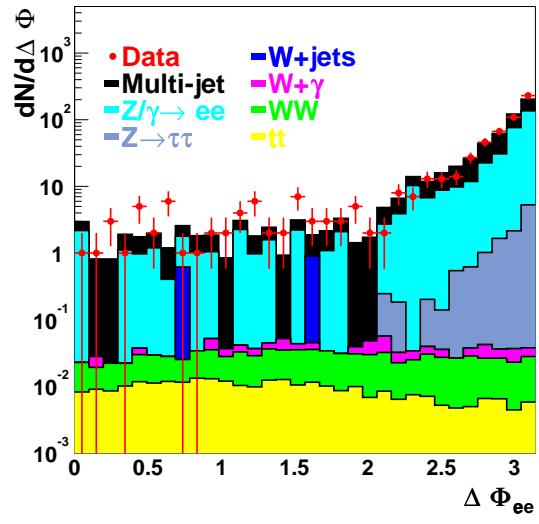
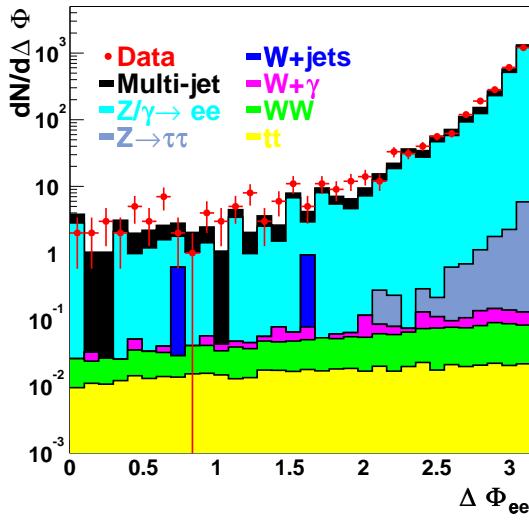


Require

- $ee$ :  $m_T(ee, \cancel{E}_T) < H_H + 20 \text{ GeV}$ ,  
and 2nd  $e$   $p_T > 20 \text{ GeV}$  if  $m_T(ee, \cancel{E}_T) < 80 \text{ GeV}$
- $\mu\mu$ :  $50 \text{ GeV} < m_T(\mu\mu, \cancel{E}_T) < 200 \text{ GeV}$

$$\Delta\phi(e, e)$$

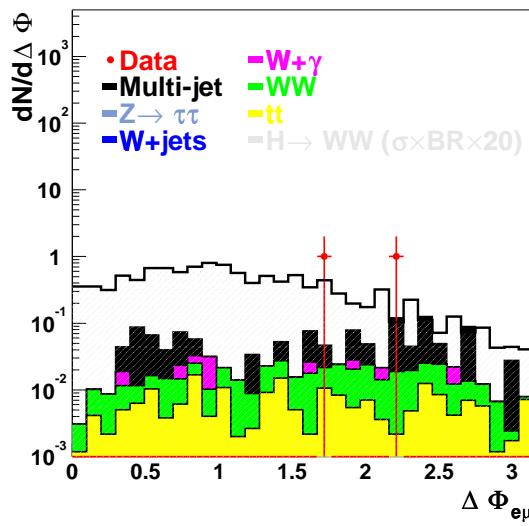
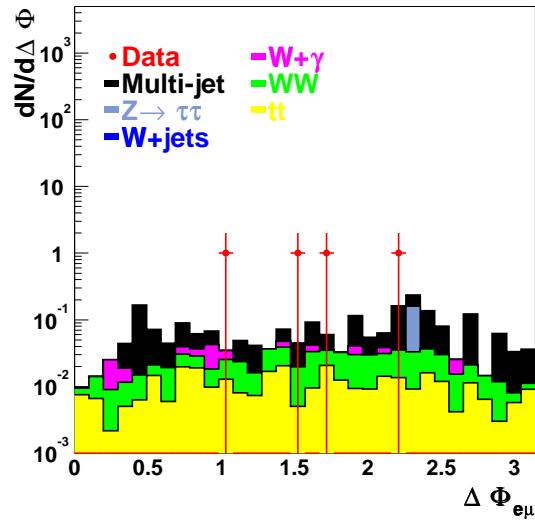
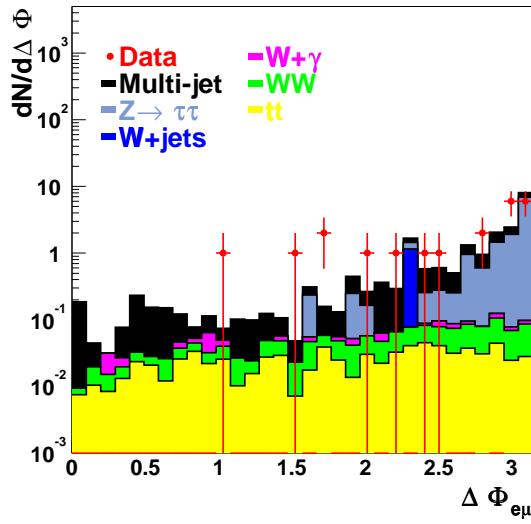
DØ Run  
II Pre-  
liminary



After  $ee$  selection (upper left),  $Z$  removal (upper right),  
 $E_T$  (lower left),  $m_T$  (lower right)

$$\Delta\phi(e, \mu)$$

DØ Run  
II Preliminary



After  $e\mu$  selection (upper left),  $Z$  removal (upper right),  
 $E_T$  (bottom)

## Event Counts

*DØ Run II Preliminary*

Source	$ee$	$\mu\mu$	$e\mu$
$Z/\gamma \rightarrow ee$	$0.00 \pm 0.03$		
$Z/\gamma \rightarrow \mu\mu$			
$Z/\gamma \rightarrow \tau\tau$	$0.0 \pm 0.2$		$0.1 \pm 0.1$
$WW$	$0.27 \pm 0.01$	$0.20 \pm 0.01$	$0.18 \pm 0.01$
$t\bar{t}$	$0.070 \pm 0.003$	$0.110 \pm 0.003$	$0.13 \pm 0.01$
$W\gamma$	$0.01 \pm 0.01$		$0.06 \pm 0.03$
$W + \text{jets}$	$0.0 \pm 1.1$		$0.0 \pm 1.5$
multijet	$0.7 \pm 0.1$		$0.40 \pm 0.04$
Total Background	$1.3 \pm 1.4$	$0.3 \pm 0.1$	$0.9 \pm 1.5$
Data	2	1	1
Expected Signal	0.13	0.18	0.21

Results in  $ee$  channel are for cuts with  $m_H = 160$  GeV/ $c^2$

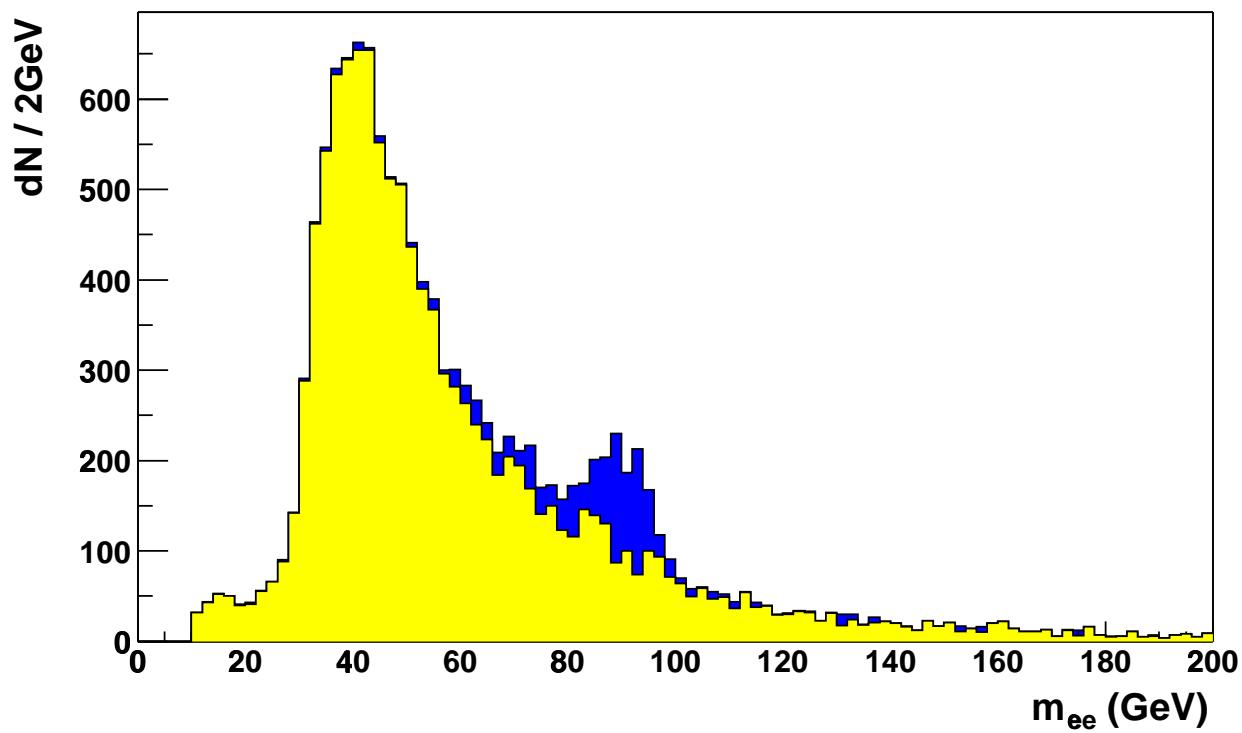
Expected signal assumes  $m_H = 160$  GeV/ $c^2$  and  $\sigma = 8.5 \times \sigma_{\text{SM}}$  due to 4th generation enhancement

## QCD Background

- Electron sources
  - jets that mimic an electron shower:  $\pi^\pm$  contained in EM cal,  $\pi^0 +$  random track
  - direct photons that overlap with a random track
  - photon conversions
  - real electrons from heavy quark decays
- Background is estimated using control data
- Method assumes  $\cancel{E}_T +$  other cuts don't bias the proportions of sources, but it doesn't depend on modeling difficult and rare processes
- Control sample: events with an electron candidate that just fails the shower shape requirements for a good electron
- Similar strategy used for muons

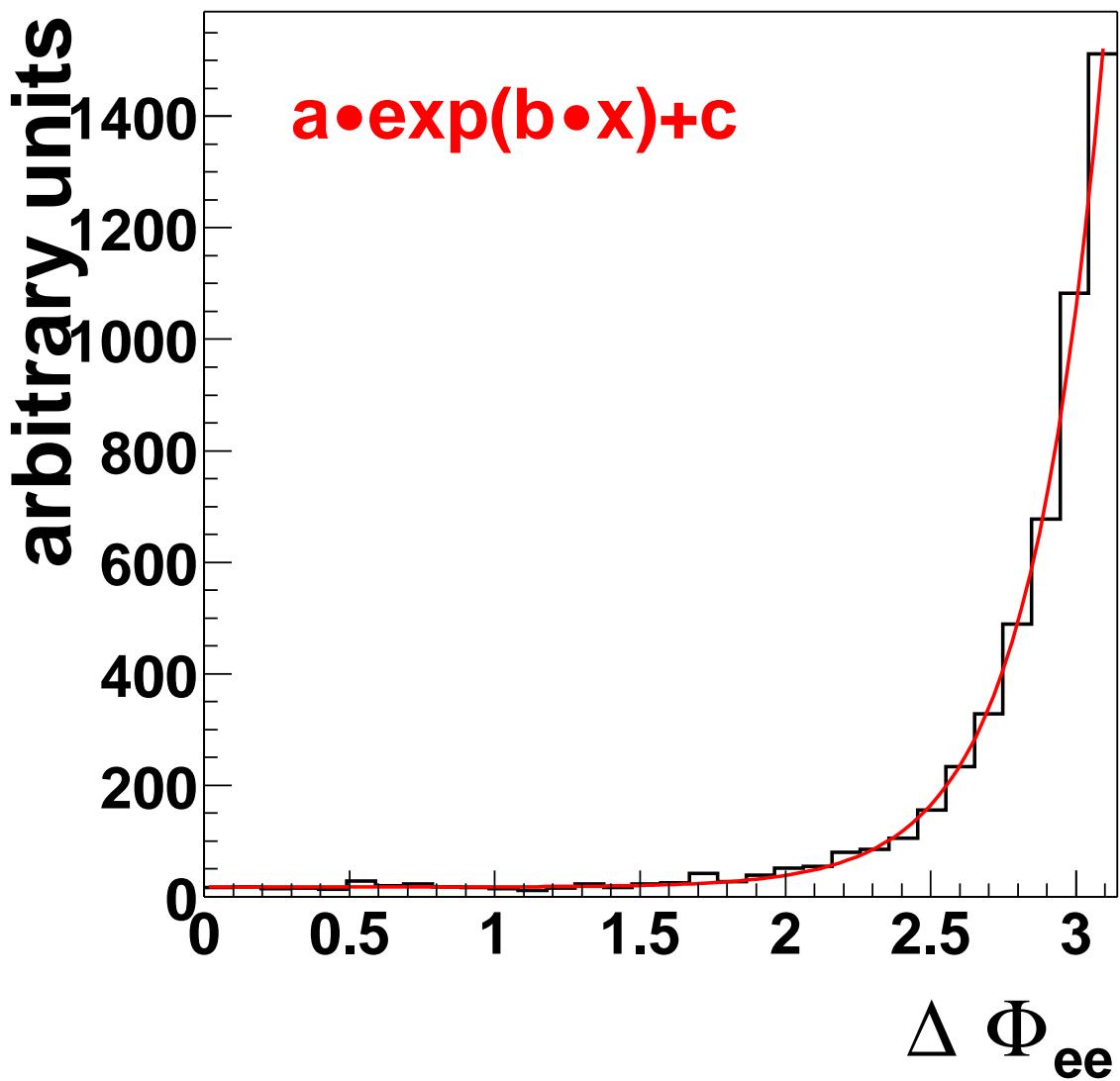
QCD control sample before (blue) and after (yellow) subtracting contribution from real  $ee$  events

*DØ Run II Preliminary*



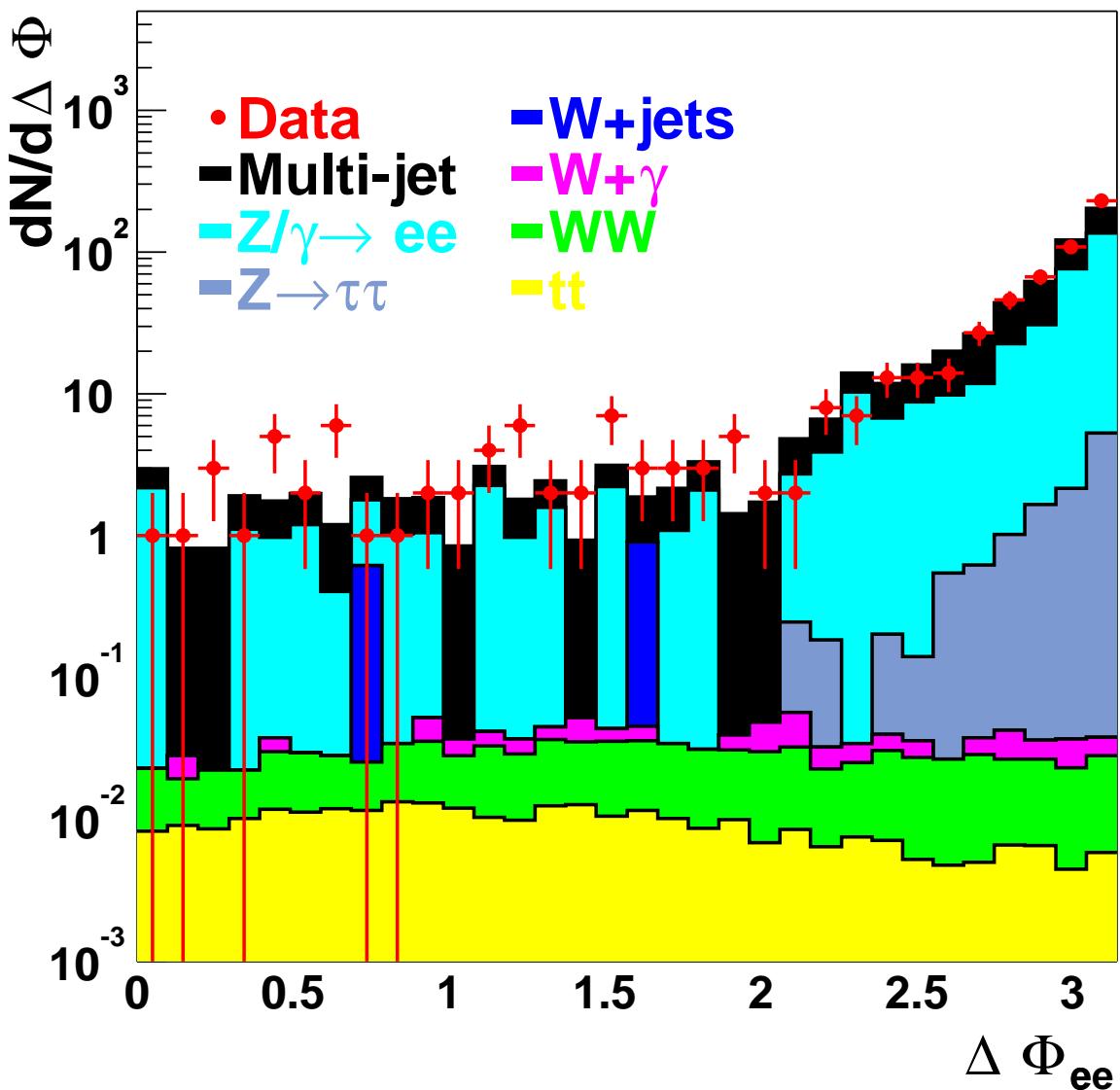
$\Delta\phi(e, e)$  distribution in QCD control sample

*DØ Run II Preliminary*



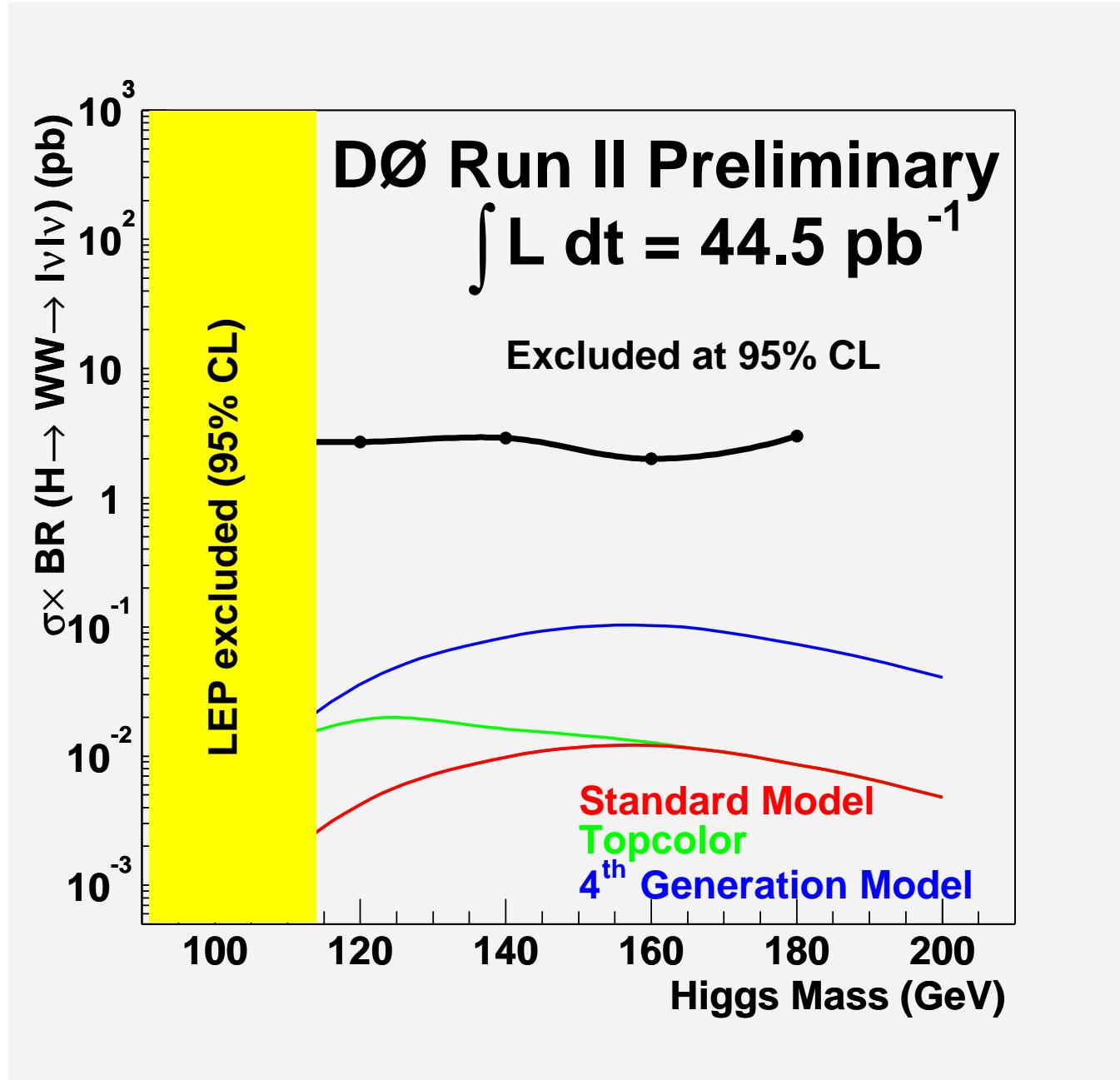
QCD background normalized to data in the  
background region  $\Delta\phi > 2$

*DØ Run II Preliminary*



## Limits

$ee$  and  $e\mu$  modes



## Summary

- DØ has searched for  $H \rightarrow WW$  with the  $ee + \cancel{E}_T$  ,  $\mu\mu + \cancel{E}_T$  , and  $e\mu + \cancel{E}_T$  signatures in the initial  $\sim 40 \text{ pb}^{-1}$  of DØ Run II data
- There are a total of 4 events with a background of about 2.5
- Improvements in electron ID and optimized event selection are expected
- With  $\sim 1 \text{ fb}^{-1}$ , we will be sensitive to plausible enhanced Higgs signals
- With  $\sim 10 \text{ fb}^{-1}$  we hope to be sensitive to SM Higgs for  $m_H$  in the region around  $160 \text{ GeV}/c^2$